amount of the barometric depression, but in many cases a glance at the photographs shows that the houses were burst apart by the expansion of the air within. The weakest joints gave way and the walls fell outward flat to the ground; the depression lasted but a few seconds; there was no resulting wind; light and fragile materials within the rooms were not disturbed, but the roofs were sometimes carried a little way before they rested on the ground. Evidently, the expansion could only work outward and upward. The violent wind was at some height above the ground, and had such a definite limit that the upper part of a building was destroyed while the lower part was untouched by it. The gusty streaks of wind flew over the earth in some places, but grazed it in others. Regions thus affected would represent either the little whirls outside of the main tornado, or the places where the lowest end of the main whirl temporarily rose above the house tops. An outward pressure of one pound per square inch over the whole side of a house corresponds to a barometric pressure within the house greater than that outside, by about two inches of mercury, and would disrupt these slightly built frame houses, whose beams are held in place by only a few nails and wooden pegs.

When a severe wind blows past any obstacle there is a slight increase of pressure on the windward side and a diminution on the leeward. The maximum amount of the increase is given by the formula $P - P_0 = 0.0000383 \times V^2$, where $P - P_0$ is the increase in pressure expressed in inches and V is the velocity of the wind expressed in miles per hour. Therefore, for a velocity of 100 miles per hour the rise of pressure will be 0.383 inch. On the leeward side of the obstacle the diminution of pressure depends so much upon the shape of the surface that no calculation can be made, but the depression on this side may be nearly as great as the excess of pressure on the windward side if the body has the requisite shape. But the photographs show that in many cases no such wind prevailed at the time that these houses were exploded; in fact, sometimes the explosion occurred just before the wind came, and in some cases it was not even followed by any wind. Therefore, the bursting of these houses is not due to wind blowing against or through or past them.

It seems plausible that a tornado begins with a local low pressure within a buoyant cloud in regions high above the ground. As the air flows upward into this low pressure and acquires a more or less violent rotary motion the surfaces of equal pressure descend toward the earth's surface about as figured by Ferrel in his theory of the waterspout and tornado. The tornado funnel cloud represents the core of the system of whirling ascending winds and funnel-shaped isobaric surfaces; the depression in the cloudy interior may be as much as 3, 5, or even 10 barometric inches, but outside of the funnel cloud and near it a depression of 2 inches and farther away 1 inch must exist in the clear air. Below the funnel, between its end and the ground, such depressions will cause a destructive upward wind, but not a horizontal wind, and that too for a second only, as the spout moves about irregularly in the air, sometimes descending to the surface of the ground and at other times retreating to the clouds. The space immediately about the spout or funnel is undoubtedly occupied by rapidly rotating and ascending air, but as the rotation and the funnel extends downward toward the ground, the relatively quiet air beneath can not be set into horizontal rotation so easily as it can be pushed upward into the axis of the funnel. We thus perceive how a system of whirling winds and low pressure sometimes works rapidly downward above a house so quickly that the air within the house lifts the roof up, leaving the walls standing, while the whirling funnel passes onward, and its winds are not felt severely at that spot. Again, the whirl having already reached the ground may pass near a building, temporarily diminishing the pressure on one side and allowing that to burst outward on the side toward the tornado, while only a slight wind affects the building. Finally, the winds that feed a fully developed tornado can not flow toward it in straight lines, but must themselves have smaller eddies and whirls and even funnel spouts, so that buildings at some distance from the path of greatest destruction may be injured by these subsidiary whirls.

The path of destruction of a tornado will vary in width from a few rods to a half mile (160 rods). In the central portion of this path the violent winds generally obliterate all traces of the explosive action due to the sudden approach of a barometric depression, but on the outer edges of the path less violent winds occur, and the evidences of explosion are frequently visible in the débris after the storm has passed.

It does not require any great fall of the barometer on the outside of the house in order to tear apart these wooden frame buildings; for instance, in a room 20 feet square and 10 feet high, whose outside wall is held to the central frame of the house by means of large nails 6 inches apart, we have to consider only 120 nails distributed around the 60 feet that form the four edges of the outside wall. If it requires 200 pounds to pull one of these nails out of its setting, we have a total pressure of 12,000 pounds distributed over the surface of the room, which is 200 square feet, therefore, an average of 60 pounds to the square foot, or less than 3 pounds to the square inch. Now, the ordinary barometric pressure of 15 pounds to the square inch, when the barometer is 30 inches high, is diminished by 3 pounds, and becomes 12 pounds to the square inch when the barometer falls 6 inches, or when it stands at 24 inches instead of 30. This corresponds very closely to the barometric pressure inside of a thunder cloud at 5,000 feet above the earth's surface. It is a pressure that can easily occur inside of a whirling waterspout or tornado. If the lower end of a cylindrical whirl of wind, within which such a low pressure prevails, passes over any given building in such a way that the air around the building rushes up to enter the whirl, then the air within the building can not escape fast enough through the chimneys and cracks. If the doors and windows are not opened in time the roof will rise or the weakest side burst outward. Even in ordinary storms the Editor has seen the loose trap door on the roof of his house, rise up, and thereby afford escape for the air within.

On Plates I, II, and III we reproduce three photographs illustrating the explosion of houses without the concurrence of any wind to disturb the interiors. We are indebted for these to Mr. H. J. Volker, Observer, Weather Bureau, St. Paul, Minn., who obtained them from Hass Bros., photographers, with permission to republish. Mr. Volker writes as follows:

> These photographs illustrate the fact so often emphasized by the Weather Bureau that buildings are not always blown down or wrecked from without, but are burst from within, upon release from outside atmospheric pressure. The sides or walls of all three wrecks show that they fell outward. The photographer's opinion is, that perhaps the chairs in No. 10 had been set up after the storm. He is sure the boards were nailed on the windows on the west side of No. 12, and he believes nothing was disturbed in No. 22 the bay window of which lies to the east. The views show clearly, that in the absence of a cellar, the center of a room is sometimes the safest place.

LOCAL WINDS THAT ARE NOT TORNADOES.

During the summer season very many local storms pass over all portions of this country without developing into typical tornadoes. In some cases the atmospheric conditions are such that a genuine tornado would be scarcely possible; in other cases, when the atmospheric conditions are favorable, the peculiarities on the surface of the ground may contribute to prevent the formation of the whirl and resulting funnel cloud. In these cases, destructive winds, hail, rain, and lightning occur, roofs are blown off, trees are prostrated, and the newspapers record a tornado, whereas to the meteorologist it is strictly speaking only a violent gust of wind, a heavy thunderstorm, a cloudburst, a hailstorm, a straight-line wind, or derecho. There are many terms applicable to these local storms, but it is certainly not proper to call them tornadoes unless the funnel-shaped cloud is actually observed. A destructive wind is not necessarily a tornado.

In the very severe storm that passed eastward, a little north of Washington, D. C., on Wednesday, August 2, 1899, the Editor studied the movements of the atmosphere until driven to shelter by the heavy rain. There was a continuous rumble of thunder from the northern sky, not an occasional clap with its echoes, but a steady angry roar that came apparently from the center of a great disturbance 5 or 10 miles distant in the north and northeast. The cirrus and alto-cumulus overflow from this stormy region extended southward over the observer, but left a portion of the western and southern sky unobscured. The lower cumuli flowed rapidly from the south and southwest toward the storm center. Below these clouds were the lowest scud formed at the upper surface of the layer of cold air that flows out from the region of falling rain and hail; these were seen in the distant north and north-northwest from 1 to 3 miles away. One could see that the severity of the storm was passing far north of the observer. But suddenly an intermediate fracto-cumulus scud was to be seen moving more rapidly and in larger volume from the rainy region in the north. In the progress of these scuds southward they could be distinctly seen to mingle with the southwest current and then return with it so as to describe from a third to a complete circle before they disappeared. Similar distinct whirls among the clouds have been seen, when our thunderstorms are northwest of Washington, forming clouds such as are represented by the concentric bands, shown on Plates XI and XII of the MONTHLY WEATHER REVIEW for May, 1898. Such whirls as this on the outskirts of a region of rain and hail do not owe their origin and maintenance to the updrift of buoyant moist ascending cloudy air. This latter is the mechanical cause of the great whirl disturbance fed by southerly winds rising up over dense cold air or over rising land and condensing in big black clouds.

RAIN GAGES AT HIGH STATIONS.

In continuation of the remarks on page 257 of the MONTHLY WEATHER REVIEW for June, Mr. F. H. Newell, Chief Hydrographer of the United States Geological Survey, desires to say that if at any time there is a chance to secure rainfall observers at high altitudes, he will be glad to cooperate by furnishing the gages.

SPURIOUS TORNADO PHOTOGRAPHS.

The article on this important subject on pages 203–4 of the MONTHLY WEATHER REVIEW for May, 1899, has elicited several interesting comments. The Editor was himself to blame for inserting a paragraph that has caused the only unfavorable comment that we have heard of.

In reference to Mr. P. Connor, of Kansas City, Mo., and Mr. F. Z. Gosewisch, whose names are mentioned in the article, it should be distinctly stated that they simply forwarded these interesting photographs to the Weather Bureau, and, therefore, were not the photographic artists elsewhere referred to in the article.

One correspondent suggests that the Weather Bureau officials may be unnecessarily critical with reference to the tornado photographs. It appears that most persons are satisfied to look upon the funnel-shaped cloud as the tornado photograph, but this is not meteorology. We wish to obtain for meteorological study prints from the original negatives showing both the ground below and the clouds above in their actual connection with the funnel cloud at any given moment. We do not wish to have the photographer alter the appearance of the funnel by especially intense printing, or by substituting another foreground or touching up the surrounding clouds. Every change made by him for the purpose of beautifying or of intensifying some special feature is likely to injure the photograph for our purposes, although it may render the picture more acceptable to the general public.

We have a few genuine photographs of tornado clouds; that is to say, neither by retouching nor by special printing processes have the meteorological features been appreciably altered. We shall be glad to learn of others that are equally reliable, as it will be a serious disappointment if the measurements and calculations that are being made with reference to tornadoes turn out to be based upon unreliable photographic prints.

GENERAL FORECASTS FOR WASHINGTON, OREGON, AND IDAHO.

On the daily weather map issued at Portland, Oreg., on July 11, Mr. Pague publishes the following:

Weather synopsis and general forecast for Washington, Oregon, and Idaho.

The map this morning presents the first pure type of summer weather conditions for the year 1899. Summer and winter weather types first appeared in former years as follows:

Summer.		Winter.	
1895	April 20	1895	November 12
1896	June 13	1896	October 20
1897	April 11	1897	October 19
1898	July 7	1898	October 1
1899	July 11		

The morning map of June 12 showed an almost pure summer high. The conditions that morning lacked a few distinct characteristics, which are fully shown this morning. Summer weather really began June 12, though to-day marks the pure type. From June 12 to date there has been a succession of highs moving from the ocean on the west or southwest, becoming central along the Washington coast, but not moving, as a whole, eastward over Washington; it was only the absence of this movement that prevented the highs being classed as "summer highs." The high shown over northwestern Washington this morning was off Cape Mendocino the morning of the 7th; its movement northward has been sluggish, but it is now moving eastward on about the forty-ninth degree, north latitude, the path of the summer highs. For months temperatures below the normal have prevailed, the sunshine has been deficient in amount, and up to June 5 rains were frequent. The change to seasonable weather conditions has now taken place, and regular periods of warm and cool weather will prevail. The presence of summer weather conditions makes possible the occurrence of hot northeast winds east of the Cascades, and while such are not probable within the next several days, they may occur with the movement of the next high, which will be about Monday or Tuesday next. Sprinkles of rain from the highs west of the Cascades and showers from thunderstorms east of them are probable at intervals, and rains from these causes are all that will occur until the appearance of winter weather conditions in September or October. Summer conditions are well marked by several days of cool weather with high fog, followed by several days of cloudless weather and higher temperatures, lasting about three days, then a recurrence to cooler. Under the recurrent conditions sprinkles of rain may occur.

THE PRESENT STATUS OF METEOROLOGY.

The Quarterly Journal of the Royal Meteorological Society for April, 1899, was received during the month of July and contains two articles that will greatly interest American readers.